Crop Profile for Onions in Washington

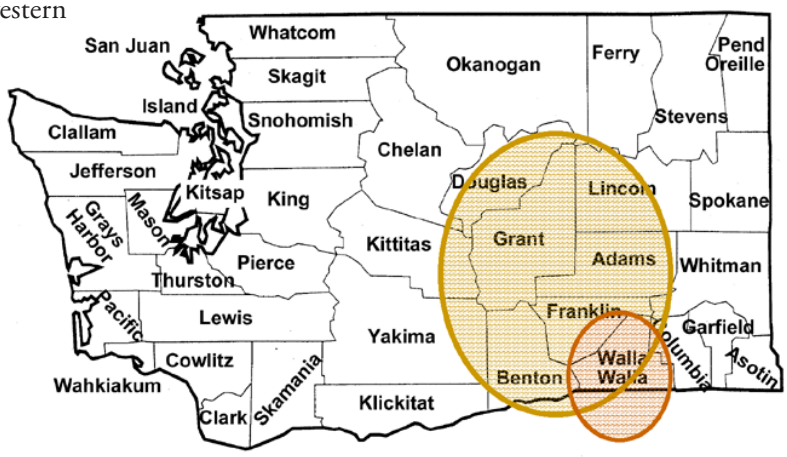
Production Facts

- Washington State ranks third in U.S. production of onions (1).
- Washington produces 16.2% of U.S. dry summer onions (1).
- In 2002, 16,000 acres of storage onions and 1100 acres of non-storage onions were harvested in Washington (1). The value of storage onions was over $91 million. Non-storage onions were valued at $9.4 million.
- Dry onions were grown on 165 Washington farms in 1997 (2).
- Average yield values in 2002 were 37 tons per acre for storage onions (3) and 18 tons per acre for non-storage onions (1).
- Production costs for storage type onions were approximately $2,607 per acre in 1999 (3). Non-storage onion production costs per acre were $3,850 in 1989 (4).

Production Regions

Most onions in Washington are grown in the eastern part of the state. Storage onion production is centered in the Columbia Basin region in Grant, Franklin, Benton, and Adams counties. The leading county for non-storage bulb onion production is Walla Walla. The Columbia Basin is the main region where onion seed is produced. Approximately 40 acres of green bunching onions are grown primarily in western Washington.

This profile will focus on storage and non-storage onions and onion seed production.



General Information

Onions, *Allium cepa,* are shallow-rooted, biennial monocots grown as an annual when desired as a vegetable, and as a biennial when seed production is desired. A cool-season crop, onions grow best in fertile, well-drained, sandy-loam type soils, but can grow in a variety of soil types. Onions in the Columbia Basin are generally grown in 3- to 4-year rotations with carrots, sweet corn, cereals, and potatoes, where potatoes sometimes follow onions. Volunteer potatoes are a serious weed therefore growers schedule rotations so that potatoes are two crop years away from onion production when possible. Other rotation partners may include field corn, wheat, peas, beans, and sometimes alfalfa. Onions are a difficult crop to grow, requiring significant growing experience, as well as being a high-value crop. For this reason most onion growers produce onions as their major crop and fill in rotation partners, usually with other vegetable crops. Onions produced in the Walla Walla region may be mono-cropped, due to their high value as a specialty onion and smaller acreages.

Bulb onion field in the Columbia Basin.

Onions are the second most important vegetable crop produced in Washington. Most of the state's crop is dry bulb onions, both storage and non-storage types, the latter intended for the fresh market. Of the fresh market onions exported to the Pacific Rim, almost all are processed at their destination markets. Some storage onions are processed as frozen or dehydrated (dehy) products. Special high-solids cultivars are required for the dehy market and are only suitable for this use. Numerous varieties are suitable for processing (the chopped or formed market), the end use being determined by the quality grade of the onion bulb. Premium processing onions become frozen onion rings, lesser grades become chopped products.

The onion industry in Washington State was started by Italian settlers in the late 1800s in Walla Walla county (4). Washington's onion industry has expanded steadily since the early 1950s development of the Columbia Basin Irrigation Project. Rapid growth in the onion industry occurred in the 1980s and 1990s with storage onion acreage increasing from 3,300 acres in 1980 to 6,800 acres in 1990. By 2000, 15,000 acres of storage onions were harvested in Washington.

Onion Types

Onions are described as short-, intermediate-, and long-day types. They are also classified by a combination of shape, environmental requirements, and market use. Examples of dry onion types are Bermudas (flat shape, short-day, non-storage), sweet Spanish (globe shape, intermediate to long-day, moderate storage), and globes (globe shape, long-day, long storage). The Walla Walla sweet onion is classified as a non-storage onion and is a unique specialty onion with low pungency, favored for fresh consumption. Storage, if any, is generally brief for the Walla Walla sweet (5).

Onion Cultivars

The Columbia Basin industry has traditionally grown cultivars that are firm, relatively dark-skinned globe onions well suited for storage (5). With the introduction of hybrid onion cultivars, most growers now plant *globe x sweet Spanish* hybrids. The sweet Spanish parentage has contributed to larger bulbs and higher yields, but with somewhat reduced storage potential compared to the traditional globe cultivars.

A number of onion cultivars are grown commercially in the Columbia Basin. The cultivar makeup changes as improved cultivars are introduced. Approximately 85 percent of the current onion production is made up of yellow cultivars, with about 10 percent red and 5 percent white

cultivars. Some of the commonly planted yellow storage cultivars are Copra, Daytona, Frontier, Pinnacle, Ranchero, Sabroso, Salem, Tamara, Tenshin, Teton, and Vaquero. Common red storage types planted in the Columbia Basin are Red Wing, Red Zepplin, and Tango. Blanco Duro is a popular white cultivar.

Yellow onions are most commonly grown in Washington.

About 10 percent of Washington onions are red types.

White cultivars account for a small percent of Washington onion production.

Onion cultivars vary in their adaptation to storage. Storage onions generally have several tight wrapper scales and a tight neck. Growers prefer cultivars with good storage qualities when the onion crop is likely to go into storage at the end of the season. Growers also consider pest resistance when selecting onion cultivars; some level of resistance is available to diseases such as Fusarium basal rot and pink root.

Cultural Practices

Planting

Onion fields in the Columbia Basin are commonly fumigated once during each rotation cycle. If the rotation includes lower-value crops, the fumigation is done prior to planting onions. If the rotation partners are carrots or potatoes, fumigation may occur the year before or the year after onions are planted, as both carrots and potatoes are also high-value crops and successful management of their pests often requires fumigation.

Prior to planting, soils are analyzed for available nutrients. Based on soil tests, phosphorus, zinc, and sulfur are usually applied prior to planting. Nitrogen fertilizer is generally applied as a side dressing or through the sprinkler or drip irrigation system. It is difficult to manage an onion crop without some nitrogen movement below the rooting zone, because of the shallow rooting system in onions. Therefore, growers often rotate with a crop such as wheat or corn following onions to capture any residual nitrogen.

Planting of dry bulb onions occurs primarily from early March through mid-April. The most active harvest period is mid-August to the end of October. A small percentage of the Columbia Basin crop is direct seeded in the fall and over-wintered to produce bulbs for early harvest. Onion transplants are also sometimes planted in early spring for even earlier harvest.

Walla Walla sweet onions are usually planted in September, and are most commonly harvested from late June through early August. Some growers hand plant seedlings (transplants, sometimes incorrectly called sets) for earlier harvest.

A uniform seedbed that allows precise seed placement is important to achieve a uniform plant stand. Plant spacing affects bulb size, shape, and yield. Increasing the spacing between plants usually results in larger, better-shaped bulbs. Most onions are spaced 3 to 4 inches or more apart, depending on the cultivar and planting scheme. Plants spaced too widely due to planting skips, disease, or other factors produce larger bulbs but may develop thick necks. Thick-necked bulbs are difficult to cure and suffer greater storage losses.

Onions are usually planted in multiple rows on beds. Beds are commonly formed at or just before planting with 2 to 12 rows planted per bed. A typical arrangement is two double rows spaced about 12 inches apart on 34- or 44-inch beds. Multiples of this arrangement are sometimes used, particularly with drip irrigation systems. Some sweet onions are planted in single rows.

Above: Seeding onions in the Columbia Basin.
Below: Sweet onion transplants.

Onion seed is expensive, therefore a majority of the crop is direct seeded with precision planters. Coated seed is used to achieve more precise plant spacing. This coating contains fungicides, typically thiram or carboxin. Seed is commonly planted about 1/4- to 1/2-inch deep. With furrow irrigation in lighter textured soils or with limited soil moisture, a depth of 3/4 inch may be required. Onions are not thinned.

On some soils, early season rainfall or irrigation before emergence creates a crust that delays or prevents emergence. When this occurs, mechanical rollers can be used to break the crust prior to crop emergence or numerous light applications of water can be made via sprinkler irrigation to reduce crusting until the crop emerges.

Cover crops are used by many growers, especially on sandy soils in windy areas, in order to reduce both crop injury and the subsequent need to replant. Careful timing is essential to kill the cover crop with herbicides or tillage to avoid suppressing onion growth. Some producers kill immature cereals with soil fumigation in the fall. Planting into the residue in the spring provides wind erosion protection.

Above: Sweet onion field.
Below: Uniformly spaced sweet onions.

Irrigation

Most onions grown in Washington State are irrigated. Furrow or rill irrigation was the most common method of irrigating Columbia Basin onions until about 1985 when sprinkler irrigation began to increase dramatically (5). Center-pivot sprinkler systems allowed higher planting density, reduced the amount of irrigation labor needed, and allowed more economical production. It is estimated that about 60% of the onions grown in the Columbia Basin are now irrigated by center-pivot systems. More recently, drip irrigation has gained popularity. Today, about 20 % of Washington's onion crop irrigated is by this method. Growers have found that onion fields grown using drip irrigation have higher yields and sometimes less disease pressure than fields that are furrow or sprinkler irrigated.

Ideally, onion seed is planted into moist soil and not irrigated until emergence is completed. One or more irrigations may be necessary before emergence to replace moisture lost during planting, overcome uneven soil conditions, or offset effects of exceptionally dry or windy weather. Under sprinkler irrigation on sandy soils, it is necessary to lightly irrigate several times to promote rapid, uniform emergence.

With sandy soils prone to wind erosion, additional irrigation may be practiced to reduce blowing soil and the resultant stand loss. Onions in the Columbia Basin normally require 20 to 24 inches of irrigation water to produce an optimum crop. With some cultivars, moisture stress at about the time bulbs start to form may limit bulb quality due to the formation of multiple growing points. Irrigation is stopped 7 to 10 days before onions are to be lifted, to help the crop mature.

Left: Center-pivot sprinklers are the most commonly used type of irrigation method for onions in the Columbia Basin today.

Above: Furrow irrigation was the most common method until 1985. Right: Drip irrigation has recently gained popularity for onions in Washington.

Harvest

The majority of onions in the state are mechanically harvested. Harvest involves a multi-step process designed to sequentially dry the onion bulb down in preparation for shipping or storing.

Mechanical harvest

The sprout suppressant maleic hydrazide is applied by 80 to 90% of storage onion growers, depending on the market destination of the onions. This chemical hastens bulb maturation by further reducing the supply of water. Maleic hydrazide is commonly applied when approximately 50 percent of the onion tops have fallen and foliage is still green, between 7 to 10 days after the final irrigation. Timing the application is critical because if applied when the crop is too immature, soft, puffy bulbs may result. In extreme cases, the growing point at the base of the bulb is killed, after which rot frequently follows. If applied too late in the season, tops have begun to die and therefore fail to transmit enough sprout suppressant into the bulb, which may reduce storage

life. Application rate of maleic hydrazide is 1.33 gallons product/A (1.99 lb. a.i./A).

Harvest involves lifting or undercutting the bulb, which is typically accomplished with a machine that severs the root system several inches below the onion bulb. Onions are then left on the soil surface to dry, a process referred to as field curing, usually for 7 to 10 days, after which they may be topped and windrowed. Mechanical toppers and topper-loaders are in common use for most Columbia Basin onions. Mechanical loaders deliver windrowed bulbs into trucks for transport to storage.

Hand harvest

Fresh market onions (particularly white onions) or specialty onions may be harvested by hand. This involves mechanical lifting, hand topping, bulb placement in burlap bags (to prevent bulb sunburn), field curing of the bagged onions, then loading bags into trucks for transport to packing facilities.

If the crop will be marketed directly from the field or soon after harvest, onions are mature enough to begin lifting when about 75 percent of the tops have fallen over and do not require maleic hydrazide application (6).

Storage

Depending upon the operation, bulbs may be mechanically sized and/or hand graded to remove diseased or defective bulbs prior to storage. Onions grown in the Columbia Basin are generally stored for at least a short period. Unlike most other fresh vegetables, onions store best under dry, cool conditions with positive air circulation. Washington producers maintain onions in both bin and bulk storage. When stored in bins, the bulbs are normally sized prior to storage. Marketing onions from storage usually occurs from November through April or May.

A properly field-cured bulb, ready for storage, should have a well-dried 2- to 3-inch neck and have at least one, and preferably two, complete, dry scales. Necks that contain moisture or are too short will not seal properly and will allow the growth of pathogens. Overly short necks also allow excessive moisture loss from the bulb in storage.

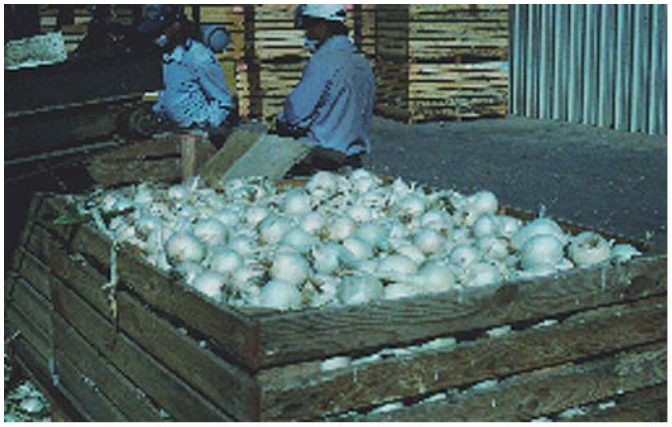
Top: Dry bulb onions after lifting.
Second: Dry onion bulbs ready for harvest.
Third: Topped and windrowed onions prior to harvest.
Bottom: Loading onions after harvest.

Even with properly field-cured bulbs, additional post-harvest curing in storage is essential. During this time, final drying of the onion neck occurs and wounds caused during harvest dry and heal. Drying of the external scales occurs most rapidly during this period. Heating to about 95° F is practiced by some storage managers to reduce Botrytis neck rot. However, heating may enhance bulb rotting caused by Aspergillus black mold if the fungus is present.

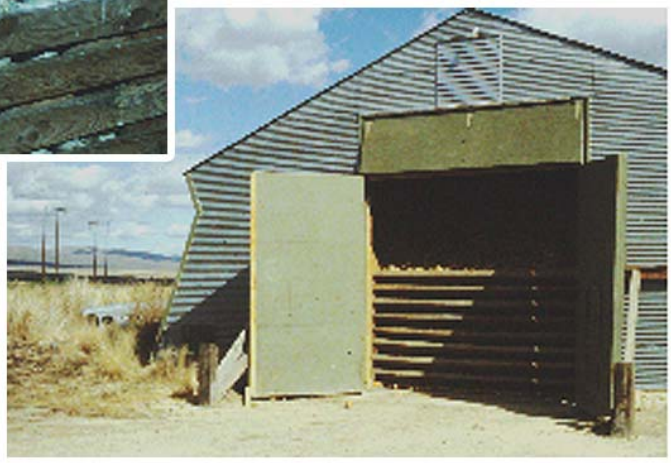
Some storage facilities in Washington are refrigerated. Most non-refrigerated storages are maintained at temperatures of 35 to 40° F when weather conditions permit. Low relative humidity (RH) is essential in storage to inhibit disease and root sprouting. Storage humidity of 65 to 70% RH is considered ideal. Bulb life is maximized at temperatures of about 32° F, but condensation during grading, packing, and shipping may occur more readily when bulbs are held at this lower temperature.

IPM Strategies

All onion growers in Washington use some integrated pest management (IPM) practices in their operation to control diseases, nematodes, insects, and weeds. Commonly used IPM practices for disease control include use of resistant cultivars, crop rotations, field scouting, cull management, sanitation, volunteer control, and judicious use of pesticides. For insect control, field scouting, sanitation, cull management, and judicious use of insecticides are the most widely used IPM practices. Scouting and crop rotation are also used in IPM programs to control weeds. When using agricultural chemicals, onion growers and commercial applicators regularly calibrate pesticide application equipment. Most agricultural chemicals are applied by commercial applicators.



Left: Sizing and binning onion bulbs prior to storage.



Right: Older bulk storage for bulb onions.

Diseases

Diseases are a serious problem for onion growers in Washington. Both large- and small-scale growers of dry bulb onions consider Botrytis neck rot, Aspergillus black mold, pink root, bacterial soft rot, and Fusarium basal rot to be serious problems. Damping off of seedlings and downy mildew can also be troublesome. Onion smut has recently been identified in the Columbia Basin but is not widespread and has not caused major crop loss. White rot, although not a widespread disease in Washington, is of special concern to growers. Iris yellow spot virus (IYSV) has recently been detected in Columbia Basin seed and bulb crops. This disease is widespread in the western U.S. and has resulted in yield losses of 20 to 30%.

Fungicides were used on 44 percent of the onion acreage in Washington in 1992 (7). This figure rose to 88 percent in 1994, and then fell to 66 percent in 2000. In 2000, the most widely used chemicals for disease management were mancozeb (Dithane, Manzate, Penncozeb), copper ammonium carbonate, and copper hydroxide (8). Of the chemical pesticides currently used on onions, mancozeb is used in the greatest amount. In 2000, 23,200 pounds of this fungicide were used to treat onions in Washington State (8). Fifteen thousand pounds of mancozeb were used in 1996 (9). Three thousand pounds of copper hydroxide and 1,500 pounds of copper ammonium carbonate were used in 2000. Among the other fungicides used in Washington are chlorothalonil (Bravo, Equus), iprodione (Rovral), and sulfur.

Growers use resistant cultivars, crop rotation, field scouting, and cull management for disease control. Proper nutrition management, avoiding crop injury during harvest, controlling volunteers, and general sanitation are also important cultural practices for disease management.

Left: Onion bulb showing symptoms of Botrytis neck rot. Note gray mold on scales and around neck. Right: Typical internal development of Botrytis neck rot.

Botrytis Neck Rot

Botrytis aclada
(formerly known as *B. allii)*

Botrytis neck rot, caused by *Botrytis aclada*, is a major disease of onion, destroying bulbs in storage and transit (10). Susceptibility varies by cultivar. In general, white cultivars are especially susceptible, but red and yellow cultivars may also sustain heavy losses. Symptoms usually appear after harvest, although infections occur in the field. The fungus enters bulbs through the neck when the tops are cut before they have cured completely or may already be present, asymptomatically, in the plant. Wounds are other points of entry. A gray mold develops between the onion scales and black sclerotia may develop around the neck of the bulb. Secondary invasion by soft rot bacteria may cause a watery rot (10).

Controls

Cultural

This disease is typically reduced by Washington onion growers through cultural practices that promote bulb maturation and timely curing, including irrigation and nitrogen management. Onion bulb necks need to be dry with no obvious moisture present before field topping, or before harvest if field topping is not practiced. While infection of the bulb through the neck is most common, the neck rot fungus may also enter through injuries occurring during harvest or handling. Providing adequate ventilation during the

first several weeks of storage to insure complete post-field curing is an important part of a neck rot management program. Selection of cultivars with good storage characteristics is also practiced. The fungus may be seed-borne, but the role of infested seed in the disease cycle is not fully understood.

Chemical

Several fungicides are registered for field application to manage the foliar phase of the disease (caused by other *Botrytis* species) although trials with these materials have not resulted in consistent benefit for controlling neck rot during storage (6). **Mancozeb (Dithane, Manzate, Penncozeb)** is used by growers to treat more than one third of the onion acreage for Botrytis neck rot (8). Many growers make multiple applications to treat for neck rot. This chemical is also used to control leaf blight and downy mildew.

Chemical	Target Pest(s)	Percent of Acreage Treated	Treatment Rate (lb ai/a)	Number of Applications	Application Method
Mancozeb	Botrytis neck rot, leaf blight, downy mildew	38	1.81	2.1	Ground, air

Chlorothalonil (Bravo) at rates of 0.75 to 2.25 lb. a.i./A and **iprodione (Rovral)** at a rate of 0.75 lb a.i./A are occasionally used by growers to treat for neck rot. Generally the lower labeled rates are used and are applied with insecticides for thrips control or may be chemigated at about two-week intervals.

Pink Root

Phoma terrestris

Pink root is caused by the fungus *Phoma terrestris*. This soil-borne fungus is common in most production areas. The disease may appear either in young seedlings or later in the growing season (6). Infected onion roots are initially yellow to tan and later turn pink or red. The roots die as the disease progresses. Reduction of the root system decreases bulb size.

Controls

Cultural

A crop rotation of three or more years between onion crops generally suppresses this organism. Since the fungus has a fairly broad host range, pink root may be present in fields never planted to onions. Corn is a good host. Many commercially available cultivars have some pink root resistance.

Chemical

Fungicides are not effective in controlling pink root. Soil fumigation effectively reduces pink root disease and fall fumigation is more effective than spring. The most commonly used soil fumigant is **metham sodium (Vapam, Sectagon)**. Application rates for Vapam and Sectagon are 100 gallons product/A and 75 gallons product/A respectively. **1,3-dichloropropene plus chloropicrin (Telone C-17)** may be used in some instances at a rate of 17.1 gallons product/broadcast acre.

Bacterial Soft Rot

Pectobacterium carotovora and other bacteria

Bacterial soft rot is a common problem in Washington when sprinkler irrigation is used. This disease is caused by *Pectobacterium carotovora* (formerly *Erwinia carotovora*) and other bacterial species. These organisms appear to gain entrance through injuries in leaf tissue from where it progresses downward through the neck and into the bulb, re-

Decay of onion bulbs caused by bacterial soft rot.

sulting in a slimy breakdown. A disagreeable odor is usually present.

Controls

Cultural

Growers avoid plant injury from insects or cultivation. Hail injury may cause extensive soft rot infection. Use of surface water sources generally resulrs in more disease potential than well water sources. If bacterial soft rot is observed in a field, growers reduce the frequency of irrigation to slow the spread of the disease. Growers cull affected bulbs and thoroughly cure onions before storing. Bulbs are stored at 35 to 40° F and less than 70 percent humidity.

Chemical

Copper ammonium carbonate (**Copper-Count-N** at a rate of 0.39 lb. a.i./A), **copper hydroxide** (**Champ** at rates from 0.39 to 0.58 lb. a.i./A; **Kocide** at a rate of 0.8 lb. a.i./A) and **copper hydroxide + mancozeb** (**ManKocide** at rates from 0.9 to 1.37 lb. a.i.(s)/A) are commonly applied via chemigation to help manage bacterial soft rot on storage onions. Growers use mid-label rates and apply material at about 10-day intervals although amounts and intervals can vary considerably.

Fusarium Basal Rot

Fusarium oxysporum

Fusarium basal rot causes occasional losses in Washington onions. *Fusarium oxysporum*, the organism that causes the disease, invades roots and as it progresses toward the bulb causes leaves to wilt and die. Typically, the disease becomes noticeable at mid-season or later as soils warm. Roots on infected plants eventually die and the basal plate shows a brown discoloration. In severe cases the entire basal plate may be rotted along with the bulb interior leaving only a hollow shell of outer scales.

Bulb tissue infection may not be evident when the crop is placed into storage, but later appears as a semi-watery decay developing from the basal plate. Infection is often associated with pink root, maggots, or other insect injury (11).

Control

Cultural

Resistance is available in some cultivars. A crop rotation of 3 to 4 years or more is practiced to help manage this disease.

Onion bulb (on right) with symptoms of Fusarium basal rot. Note absence of roots and basal plate discoloration.

Chemical

Fungicides do not suppress Fusarium basal rot in onions. Results with soil fumigants for control have been erratic.

Downy Mildew

Peronospora destructor

Downy mildew is found primarily in the early summer onion production area of southeastern Washington (6). Systemic infection occurs when the growing point is invaded. All subsequent growth becomes infected and appears dwarfed, pale, and distorted. Local infections may develop under humid, cool conditions, appearing as violet-colored, downy areas on leaves. Upon dying, these areas appear as light-colored, diffuse spots.

Downy mildew symptoms on onion foliage.

Control

Cultural

A crop rotation of 2 to 3 years is beneficial in downy mildew manage-

ment. Some growers isolate commercial bulb crops from onion seed crops and away from cull piles. Weed control can increase air circulation around plants and shorten the time dew stands on the foliage (12).

Chemical

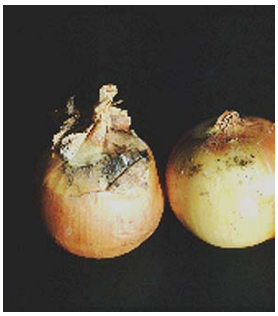
Several fungicides are registered and effective to control this disease. **Copper ammonium carbonate (Copper-Count-N)** and **copper hydroxide (Champ, Kocide)** are used by onion growers in Washington State to control downy mildew, each on about 16 percent of onion acreage (8). Multiple applications are often used.

Chemical	Target Pest(s)	Percent of Acreage Treated	Treatment Rate (lb ai/A)	Number of Applications	Application Method
Copper ammonium carbonate	Downy mildew	16	0.2	2.9	Chemigation
Copper hydroxide	Downy mildew	16	0.8	1.4	Chemigation

Mefenoxam (Ridomil Gold) has been found to be an effective systemic for control of downy mildew. **Azoxstrobin (Quadris), chlorothalonil (Bravo, Equus), iprodione (Rovral), mancozeb (Dithane, Manzate, Penncozeb), maneb**, and **sulfur** are alternative chemicals used to control this disease.

Black Mold
Aspergillus niger

Aspergillus niger is the cause of black mold in onions. This fungus is common in soil and crop debris and is also seedborne. It is a disease of onions in storage and transit. It also affects a large number of other vegetable and fruit crops (11). High temperatures and humidity favor black mold development.



Black mold infection on the neck of onion bulbs.

Infection occurs on the bulb as the foliage dies down at maturity. The necks and shoulders of infected bulbs develop black spores and affected scales may shrivel. The spores are arranged as streaks along veins on and between the outer scales. As the disease progresses, the fungus may infect the fleshy inner scales. The entire outer surface may become black and secondary diseases, such as bacterial soft rot, may cause decay.

Controls

Cultural

Growers avoid holding the crop in the field once adequate curing has occurred and they cease harvest during very warm weather (when bulb temperatures reach 85°F has been suggested). Prompt drying of bulbs after harvest and careful handling to avoid bruising are an important part of cultural control of black mold. In storage, maintaining low temperatures and low humidity minimizes losses caused by this disease. No resistant cultivars are available.

Chemical

In Washington, fungicides are not used to control black mold.

White Rot
Sclerotium cepivorum

White rot, caused by *Sclerotium cepivorum*, is a devastating disease of onions that causes infected plants to wilt and die (6). Outer leaves decline first. Bulbs rot and are typically covered with a white cottony growth in which tiny, black sclerotia may be embedded. The disease may persist in the soil for as long as 25 years. Chemical and cultural control practices have little effect once the disease is introduced. White rot is spread by contaminated bulbs or transplants of any member of the

onion family or on contaminated bins, vehicles, or tillage equipment. It is not spread by seed.

Symptoms of white rot on onion.

Controls

Cultural

In Washington, growers use sanitation to avoid introducing white rot via contaminated soil carried on equipment or other means. Growers plant only disease-free transplants. Exclusion is the best way to control white rot. Once this disease is established in a field, it is very difficult to grow any *Allium* spp. successfully.

Chemical

Growers do not generally use chemicals to control white rot. Soil fumigation using **metham sodium** (**Vapam** at rates of 100 gallons product/A; **Sectagon** at rates of 75 gallons product/A) has provided some control. Under most conditions, even the best chemicals control only a portion of the disease and soils become useless for production of onions and other *Allium* spp. (6).

A Washington State Department of Agriculture quarantine to limit movement of white rot into Adams, Franklin and Grant counties from contaminated areas has been adopted. This quarantine prohibits importing bulbs, transplants, or other vegetative material for propagation unless the materials are certified free of white rot by the state department of agriculture in which the material originated. Agricultural equipment, vehicles, or bins used in other onion areas must be sterilized before being brought into the quarantine area.

Iris Yellow Spot Virus (IYSV)

With the recent identification of iris yellow spot virus in Columbia Basin seed and bulb onions, Washington became the last of the western-U.S. onion-producing states to detect IYSV. This disease, which is vectored by onion thrips (see Insects section) and perhaps other species, is spreading rapidly in onion growing areas. IYSV causes early plant death, reduced bulb size and reduced yields. Losses of 20 to 30% yield have been documented in Colorado. The disease may cycle between over-wintered seed crops and commercial bulb crops and may survive in cull or volunteer onions.

Symptoms of IYSV are white to cream-colored lesions on leaves. The lesions are initially round but elongate into linear or elliptical shapes along the leaf axis. On onion seed scapes (seed stalks), the lesions are generally elliptical to triangular, often with a green center.

Controls

Cultural

Growers avoid close proximity of onion seed and bulb fields in an effort to provide some IYSV suppression. Cull and volunteer management practices are also useful. Some differences in cultivar susceptibility have been noted in Colorado, however further research is indicated.

Chemical

This disease must be managed indirectly through control of thrips. Recent Colorado research suggests that **Actigard**, a systemic acquired resistance (SAR) compound, reduced IYSV in field trials. This product is not registered in Washington on onions at this time.

Nematodes

Nematodes are recognized as a problem more by large-scale growers than by small scale-growers. Onion crops in Washington are occasionally attacked by stubby-root and, in some small areas, by stem and bulb nematodes. Root knot nematodes can cause stand and yield reductions but are generally managed by crop rotation and/or soil fumigation for disease control.

Stubby-Root Nematode
Paratrichodorus allius and *P. minor*

The most important nematode pest of onions in Washington is the stubby-root nematode, *Paratrichodorus allius* and *P. minor*. Stubby-root nematodes affect a wide range of plant species and are particular problems in very sandy soils with grasses or cereals in the crop rotation. Roots of onions attacked by the stubby-root nematode are extremely short with a yellow to brownish cast and plants become stunted.

Controls

Cultural

Crop rotation is the primary cultural control method used by onion growers. In particular, growers try to avoid following mint, which is a host for the stubby-root nematode.

Chemical

1,3-dichloropropene (**Telone II** at a rate of 18 gallons product/broadcast acre) and **oxamyl** (**Vydate L** at 2 gallons product/banded acre) are the most common treatments for stubby-root nematodes.

Insects

Thrips and maggots are the most serious insect pests of onions in Washington State. Thrips, both onion thrips and western flower thrips are an increasing problem for many growers in the Columbia Basin. Onion maggots are particularly troublesome in western Washington and seed corn maggots damage crops in the Columbia Basin. Aphids, armyworms and cutworms, leafhoppers, leafminers, and wireworms are occasional pests.

In 1992, insecticides were used on 87 percent of onion acres in Washington (7). According to USDA data, eight years later, in 2000, the percent of onion acreage treated with insecticides had fallen to 42 percent (8). In terms of acreage, chlorpyrifos (Lorsban), lambda-cyhalothrin (Warrior T), and malathion were the insecticides most widely used on onions in Washington in 2000. Twenty-six hundred pounds of chlorpyrifos was also used during the 2000 season. Azadirachtin (Neemix), azinphos-methyl (Guthion), cypermethrin (Ammo), diazinon, dimethoate, methomyl (Lannate), permethrin (Ambush, Pounce), petroleum distillates, and zeta-cypermethrin (Mustang) are occasionally used to treat for insect pests in onion fields in Washington. (Note: As of December 2003, neither Guthion nor Dimethoate were registered for use on onion. They were, however, in 2000.)

All bulb onion growers in Washington use field scouting and sanitation as part of their IPM program for insects. A majority of growers also use cull management and crop rotation.

Onion and Western Flower Thrips
Thrips tabaci and *Franklinella occidentalis*

Thrips are small, slender insects. Onion thrips, *Thrips tabaci*, predominate in the earlier part of the growing season with western flower thrips, *Franklinella occidentalis*, abundant later in the season. Adults are pale yellow to light brown

Chemical	Target Pest(s)	Percent of Acreage Treated	Treatment Rate (lb ai/A)	Number of Applications	Application Method
Lambda-cyhalothrin	Thrips, onion maggot, leafminer, armyworm	26	0.03	2.3	Ground, air
Malathion	Thrips, onion maggot	2	1.09	1	Ground, air

in color, with feathery wings (13). It is very difficult to distinguish between these two pests without using a dissecting microscope. Young thrips, called nymphs, are pale yellowish-green and wingless. Thrips thrive in hot, dry conditions and are more damaging when such conditions persist for much of the growing season. These insects have a wide host range, including cereals and broadleaf crops. Both adults and nymphs feed on foliage. When foliage is severely damaged, it becomes scarred and silvery in color. Yields can be reduced and percentage of large bulbs decreased. Onion thrips infest bulbs beneath the dry scales causing increased decay losses during storage and silvery areas where they feed, rendering the onions reduced in value or unsalable. Onion thrips are vectors of iris yellow spot virus, a disease of both bulb and seed onions, recently identified in Washington (see Disease section).

Damage to onions in storage caused by thrips.

Controls

Cultural

Thrip numbers are monitored to determine when the first insects enter a field in the spring and to determine when a treatment threshold (average 3 insects per plant) is reached. Since these tiny insects are commonly found at the base of new leaves closest to the neck, growers remove or spread these leaves to determine if thrips are present. When possible, growers generally avoid planting onions near cereals or grass seed fields, as thrip populations build up in these crops in the spring and migrate to nearby fields as these crops mature. Growers have found that overhead irrigation provides a measure of suppression.

Chemical

Insecticides are used when thrip populations reach an average of three insects per plant. In 2000, **lambda-cyhalothrin** (**Warrior T**) was used on more than one quarter of the onion crop in Washington (8). Many growers use multiple applications of lambda-cyhalothrin. This insecticide is also used to control armyworm, onion maggot, and leafminer. A small percentage of the onion acreage in Washington is treated with **malathion** for thrips control.

Oxamyl (**Vydate L** at a rate of 0.5 lb. a.i./acre) is also used for control of thrips. Oxamyl is particularly effective under sprinkler and drip irrigation due to root uptake of the chemical. Onion growers have tried many other chemicals for control of thrips. **Azadirachtin** (**Neemix**), **azinphos-methyl** (**Guthion**), **cypermethrin** (**Ammo**), **diazinon, methomyl** (**Lannate**), **permethrin** (**Ambush, Pounce**), **petroleum distillates**, and **zeta-cypermethrin** (**Mustang**) are used occasionally in onion fields. The maximum rate of water recommended on the insecticide label is used. Use of ground spray equipment is preferred, at least in the earlier part of the growing season. Resistance to organophosphates and pyrethroid insecticides is present in western flower thrips populations and a degree of tolerance to pyrethroids noted in both thrips species. (Note: As of December 2003, Guthion was not registered for use on onion. It was, however, in 2000.)

continued

Onion Maggot and Seed Corn Maggot
Hylemya antiqua and *Hylemya platura*

The onion maggot and seed corn maggot are the larvae of small fly species, *Hylemya antiqua* and *H. platura*, that feed on onion tissue at or below the soil line (6). Adult female flies deposit eggs on or near developing onion plants. Upon hatching, the maggots burrow through soil into the plant or directly into the plant, often creating an entry site for soft rot bacteria or other pathogens. Onion maggot has not been identified in the Columbia Basin. Seed corn maggot causes damage in onion and other crops in the Columbia Basin with some regularity. Preventative treatment is practiced in areas where maggot damage is frequent.

Seed corn maggot adult flies caught on sticky trap.

Controls

Cultural

Crop rotation is an effective cultural control practice used by many growers. To discourage maggots, cull onions may be buried under 2 feet or more of soil. Avoiding fields with large amounts of crop residues and not incorporating green cover crops are best management practices used by growers for seed corn maggot control.

Chemical

Several insecticides are registered for application at planting. **Chlorpyrifos** (**Lorsban**) is used on nearly 20 percent of onion acreage in Washington (8).

Chemical	Target Pest(s)	Percent of Acreage Treated	Treatment Rate (lb ai/A)	Number of Applications	Application Method
Chlorpyrifos	Onion maggot	19	0.87	1	Ground

Other chemicals registered for control of maggots are **azadirachtin** (**Neemix**), **cypermethrin** (**Ammo**), **diazinon, malathion, permethrin** (**Ambush, Pounce**), and **zeta-cypermethrin** (**Mustang**). These are, however, only rarely used by growers in Washington.

Wireworms
Limonius spp.

Wireworms, *Limonius* spp., are the elongated, glossy yellow to red-brown larvae of click beetles. They range in length from 3/8 to 1 inch (6). They complete their juvenile stages in the soil, where they feed on plant tissue for 2 to 5 years. Affected plants may have a wilted appearance and damage commonly occurs in patches of the field. These insects, if present in high numbers, can eliminate portions of onion stands.

Controls

Cultural

Crop rotation is one management activity used by growers. Alfalfa, if kept free of weeds, can be particularly helpful in reducing wireworm populations.

Chemical

Soil fumigation is effective against wireworms, especially when populations are high. Several insecticides, including diazinon, are registered for control, but must be applied prior to planting and are generally not used.

Weeds

Right: Weeds can smother young onions.

Below: Lambsquarters is a common weed in Columbia Basin onion fields.

Weeds are a major concern for onion growers in Washington. Onions have foliage that is sparse, slow to develop, and competes poorly with weeds. Weeds reduce yields of onions by direct competition for nutrients, water, and space. Large weeds can reduce air movement in onion fields, increasing the risk of disease. Heavy weed growth may slow drying down of foliage prior to harvest. Harvesting operations are more difficult where weeds have not been properly managed.

In 1992, herbicides were used on 54 percent of Washington onion acres (7). Since 1994, however, nearly all onion acres have been treated annually with herbicides. Ninety-five percent of the onion acreage was treated in 2000 (8). All Washington onion crops have at least one hand weeding during the growing season.

Annual and Perennial Broadleaf and Grass Weeds

Weeds common in the Columbia Basin include lambsquarters (*Chenopodium album*), common groundsel (*Senecio vulgaris*), pigweeds (*Amaranthus* spp.), common purslane (*Portulaca oleracea*), Russian thistle (*Salsola iberica*) and Canada thistle *(Circium arvense*). Annual grasses, such as barnyardgrass (*Echinochloa crus-galli*), can be a serious problem for onion growers. Kochia (*Kochia scoparia*), various nightshades (*Solanum* spp.), and ladysthumb (*Polygonum persicaria*) are among the other weeds that can be troublesome in onion fields. Volunteer potatoes can be a major problem in fields where this crop has been grown in rotation.

Control

Cultural

A majority of growers use field selection, crop rotation, scouting, and nutrition optimization for weed management. Some large- and most small-scale growers use cultivation as a key component of their weed control programs; some use mechanical cultivation during the growing season in addition to the cultivation that takes place when the field is prepared before planting. Hand weeding, primarily using long handled hoes, is required at least once per season by all growers to control large weeds that have escaped other methods of control.

Hand weeding onions is costly and used sparingly by most growers.

Chemical

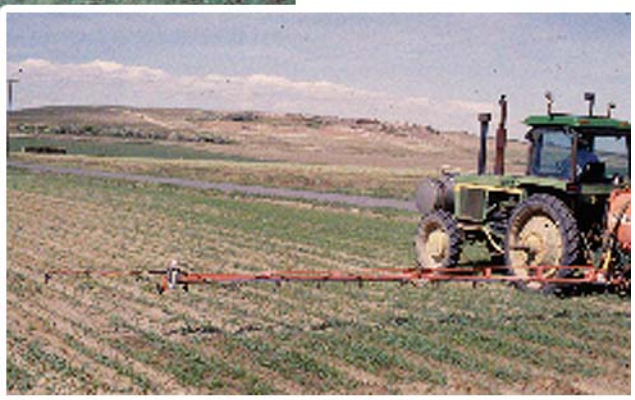
In terms of acreage treated, o**xyfluorfen** (**Goal**) and **pendimethalin** (**Prowl**) are the most commonly used herbicides. These chemicals are each used on more than 80 percent of the total Washington onion acreage (8). **Bromoxynil** (**Buctril, Bromox**) is used on approximately 60 percent of the onion acreage. Use of pendimethalin has increased dramatically since 1996, when only about 40 percent of the onion acreage was treated with this chemical (9). In 2000, 9,900 pounds of pendimethalin were used on onions in Washington (8). This figure represents an increase of 4,600 pounds over the amount used in 1996. Three thousand pounds of oxyfluorfen, 2,000 pounds of bromoxynil, 1,400 pounds of **glyphosate** (**Roundup**), and 1,000 pounds of **sethoxydim** (**Poast**) were used on onions in Washington State in 2000 (8).

Herbicides are applied by ground equipment, aircraft, and via chemigation. Bromoxynil, **fluazifop-P-butyl** (**Fusilade**), and oxyfluorfen are often applied several times per season to manage weeds.

Bromoxynil and oxyfluorfen are used to control broadleaf weeds. For control of grasses, onion growers use **Clethodim** (**Select**), fluazifop-P-butyl, and sethoxydim. Pendimethalin and glyphosate control both broadleaf and grass weeds. Bromoxynil is registered for use in Washington only east of the Cascade Mountains (14).

Metham sodium (**Sectagon, Vapam**), a fumigant used for suppression of some diseases (see Disease section), also controls weeds and can reduce the need for herbicides.

Chemical	Target Pest(s)	Percent of Acreage Treated	Treatment Rate (lb ai/A)	Timing	Number of Applications
Bromoxynil	Broadleaves	62	0.12	Post-emergence	1.6
Clethodim	Grasses	2	0.13	Post-emergence	1
Fluazifop-P-butyl	Grasses	26	0.2	Post-emergence	1.8
Glyphosate	Broadleaves, grasses	20	0.46	Pre-emergence	1
Oxyfluorfen	Broadleaves	88	0.13	Post-emergence	1.7
Pendimethalin	Broadleaves, grasses	85	0.58	Early post-emergence	1.2
Sethoxydim	Grasses	32	0.2	Post-emergence	1



Left: Shielded sprayers are used to apply herbicides post-emergence.

Below: Spraying weeds prior to onion emergence.

Pest Control Issues

Onion growers in Washington integrate a wide variety of cultural methods into their pest management systems. Use of resistant cultivars, crop rotation, field scouting, and cull management are among the critical components for a successful onion crop. The chemical control methods mentioned in this profile are important for situations where pest pressure is high.

Perennial broadleaf weeds and diseases are considered by growers to be the most serious pest control problems in Washington. Herbicides are widely used in conjunction with mechanical cultivation and hand weeding. The most common and successful herbicide applications combine a broadleaf herbicide with a grass herbicide. With relatively few herbicides registered for use on onions, it is important that growers have oxyfluorfen, pendimethalin, bromoxynil, sethoxydim, fluzifop-P-butyl, and glyphosate available to them. Herbicides are needed to control weeds prior to the two-leaf stage, when chemicals such as oxyfluorfen cannot be applied. Also, currently registered herbicides, if not carefully applied, can damage the crop (14).

Insects often pose serious problems for onion growers in Washington. Thrips are an increasing problem in the Columbia Basin, both for the direct damage they can do and for their ability to vector IYSV. Not only are insect problems in general increasing, thrips are becoming resistant to some commonly used chemicals, such as cypermethrin. Growers often alternate lambda-cyhalothrin with other chemicals such as oxamyl and chlorpyrifos. Alternatives are needed for resistance management. A cultivar resistant to thrips would be valuable to the industry. Onion maggots are troublesome in western Washington; more control options would be useful.

Botrytis neck rot, Fusarium basal rot, bacterial soft rot, Aspergillus black mold, and pink root are the most serious disease problems in Washington. Damping off of seedlings and downy mildew can also be troublesome. There is potential resistance to some of the chemicals used to manage downy mildew, such as mefenoxam and azoxystrobin. Onion smut has recently been identified in the Columbia Basin and has the potential to become a major disease problem for growers. At present, white rot is not a widespread problem, but this disease can be devastating to the prospects of growing onions or any *Allium* species. A fungicide effective against white rot would be a valuable addition to future pest control tools.

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References

(1) WSDA, Washington Agricultural Statistics Service. 2003. Washington Agricultural Statistics Annual Bulletin. http://www.nass.usda.gov/wa/homepage.htm

(2) USDA, National Agricultural Statistics Service. 1999. 1997 Census of Agriculture. http://www.nass.usda.gov/census/

(3) Hinman, H.R., and G. Pelter. 1999. Estimated Cost and Returns for Producing Onions, Columbia Basin, Washington, Washington State University, EB 1753. (2003 update in press.)

(4) Hinman, H.R., W. Gary and M. Gernghini. 1989. 1989 Cost of Producing Walla Walla Sweet Onions in the Walla Walla Valley. Washington State University, EB 1520.

(5) Pelter, G.Q., Washington's Onion Industry. In: Washington Agricultural Statistics 1994-1995.

(6) Pelter, G.Q., E.J. Sorensen, R.E. Thornton, and R. Stevens. 1992. Dry Bulb Onion Production, Washington State University, EB 1693.

(7) WSDA, Washington Agricultural Statistics Service. 1995. Washington Agricultural Chemical Useage-Dry Onions.

(8) USDA, National Agricultural Statistics Service. 2001. Agricultural Chemical Useage - 2000 Vegetable Summary.

(9) USDA, National Agricultural Statistics Service, Vegetables - 1998 Annual Summary.

(10) Johnson, D.A. 1986. Botrytis Neck Rot of Onion, Washington State University, EB 1359.

(11) Pacific Northwest Plant Disease Control Handbook. 2002. Oregon State University.

(12) Johnson, D.A., and C.G. Shaw. 1985. Downy Mildew of Onion, Washington State University, EB 1310.

(13) Pacific Northwest Insect Control Handbook. 2002. Oregon State University.

(14) Schreiber, A., and L. Ritchie. 1998. Washington Minor Crops, Washington State University.

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